METHODS, SYSTEMS, AND TERMINALS FOR LOAD COIL SWITCHING

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Field of the Invention

[0001] The present invention relates to communications networks, and more specifically to the management of load coils in communications networks.

Background of the Invention

[0002] Modern communication networks, such as the Public Switched Telephone Network (PSTN), are used to transmit voice and data signals around the world. For example, **Figure 1** illustrates a conventional communications network, including the PSTN **100**. As shown in **Figure 1**, a central office (CO) **110** of a local telephone company may provide users or subscribers **120a-c** with access to the PSTN **100**. The portion of the network between the CO **110** and the users **120a-c** may be referred to as the local loop **130**. The local loop **130** may include a series of transmission line cables **140a-c** which may be carried via telephone poles and/or buried underground between the CO **110** and the users or subscribers **120a-c**. The design and operation of the PSTN **100** and the CO **110** are well known to those having skill in the art and need not be described further herein.

[0003] The transmission line cables **140a-c** used in the local loop **130** may each include a plurality of twisted wire pairs, known as POTS (Plain Old Telephone Service) lines. These wire pairs can have substantial capacitance, which may result in a change in impedance with the length of the transmission line. As is well known in transmission line theory, an improperly matched transmission line and load impedance may result in only part of a transmitted signal to be absorbed, with the remainder being reflected back on the twisted pair, which may result in interference on the line and thus signal distortion and/or degradation. As these capacitance effects may increase with transmission line length, they may directly impact the voice band (300 Hz to 3000Hz) such that higher voice frequencies may be subjected to greater loss or attenuation. As the length of the transmission line is increased beyond 18,000 feet, this attenuation may pose a significant obstacle to voice transmission.

[0004] **Figure 2** illustrates a conventional local loop, including a transmission line cable between a CO **210** and a user **220**. Referring to **Figure 2**, load coils **230a-c** are inductors which may be placed on the transmission line **240** to compensate for the capacitive effects at increased transmission line lengths. The load coils **230a-c** may be inserted in series with the wire pairs of the transmission line **240** at specific intervals (such as every 6000 feet), so that the known capacitance of the wire pairs may be balanced by the inductance of the load coils **230a-c** to maintain a predetermined line impedance. Thus, the effective capacitance of the loop may be reduced, balancing the attenuation across the voice band. As a result, signal reflection may be lowered and voice quality may be improved.

[0005] A potential drawback of load coils is their effect on broadband data transmission, such as DSL (Digital Subscriber Line). Since each load coil may appear as extremely high impedance to high-frequency data transmission, DSL and other broadband connections may not be effectively deployed on loaded circuits. In other words, the load coils act as low-pass filters, so that high frequencies cannot pass through the coils. As such, when a user or subscriber wants high frequency service, each and every load coil located on the transmission line between the CO and the user must be "unloaded" or bypassed from the wire pair connected to the particular user.

[0006] **Figure 3** illustrates a conventional load coil enclosure installed on a transmission line section. As shown in **Figure 3**, the transmission line section **300** includes a load coil enclosure **320** and a transmission line **340**. The load coil enclosure **320** includes a plurality of load coils, each of which is connected to a respective one of the plurality of twisted wire pairs included in the transmission line **340** through a splice closure **350**. The splice closure **350** is a terminal casing designed to cover the area of the transmission line **340** where the plurality of wire pairs have been exposed for repair, maintenance, and/or installation of network elements. Although the load coil enclosure **320** and splice closure **350** are illustrated as mounted on a telephone pole **360**, such enclosures may also be mounted in cabinets, underground manholes, or the like.

[0007] In order to bypass a load coil, the location of the load coil enclosure in the outside environment may need to be determined. After gaining access to the load coil enclosure, the specific wire pair servicing the user may need to be separated from the potentially hundreds of wire pairs typically found in transmission line cables so that the corresponding load coil may be bypassed by splicing the wire pair around the

load coil. The cable may then need to be recovered with metallic and plastic sheaths, pressurized, and tested for leaks. Alternatively, a user may require that a disconnected load coil be re-connected to the wire pair in a similar manner. In either case, it may typically take two technicians eight hours or more to complete the splicing operation for each load coil on a user's wire pair. Further, bypassing or re-connecting these coils may require coordination between engineering teams and construction crews, resulting in service delays to the customer.

[0008] A load coil enclosure that includes load coils and switches within the same housing such that each load coil can be connected or disconnected from a wire pair using a corresponding switch rather than physically removing each coil from the wire pair is discussed, for example, in U.S. Patent Nos. 5,929,402 and 6,281,454 to Charles et al. However, in order to use such switchable load coil enclosures, a telephone company may be required to replace load coil enclosures that are currently in use. As load coils have been used on transmission lines since the late 1960s, thousands of load coil enclosures are already in place today. To replace all of these existing enclosures with the switchable load coil enclosures of Charles et al. may involve a tremendous cost to the telephone companies, and as such, may be undesirable.

[0009] In view of the foregoing, it may be desirable to provide a solution that quickly allows technicians to add or remove load coils from transmission lines without requiring time-consuming splices, service delays, and/or replacement of existing load coil enclosures.

Summary of the Invention

[0010] Some embodiments of the present invention provide methods, systems, and terminals for load coil switching. According to some embodiments of the present invention, a method for constructing a transmission line unit so that load coils can be selectively connected to a transmission line may include: providing a transmission line section having a transmission line and a number of load coils electrically connected to the line; and connecting a switch terminal having a number of switches to the transmission line section, such that each of the switches is electrically connected to a respective load coil and configured to selectively connect the respective load coil to the transmission line. The load coils may be provided in a load coil enclosure that is separate from the transmission line and the switch terminal.

[0011] In other embodiments of the present invention, each switch may have a first switch position that connects the respective load coil in series with the transmission line, and a second switch position that disconnects the respective load coil from the transmission line. The transmission line may include a number of incoming and outgoing wire pairs, such that the first switch position electrically connects the respective load coil in series with a respective incoming and outgoing wire pair, and such that the second switch position electrically connects the respective incoming and outgoing wire pair to bypass the respective load coil. The first switch position can connect the respective load coil in series with the transmission line to configure the line for voice service, and the second switch position can disconnect the respective load coil from the transmission line to configure the line for DSL service. In addition, each of the switches may be configured to be controlled electronically from a remote location.

[0012] Further embodiments of the invention may include transmission line systems and terminals for selectively connecting load coils to a transmission line according to methods as described above. Other systems, methods, and/or terminals according to embodiments will be or become apparent to one with skill in the art upon review of the following drawings and detailed description. It is intended that all such additional systems, methods, and/or terminals be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

Brief Description of the Drawings

[0013] **Figure 1** is a schematic diagram that illustrates a conventional communications network.

[0014] **Figure 2** is a schematic diagram that illustrates a conventional local loop in a communications network.

[0015] **Figure 3** is a side view of a conventional load coil enclosure installed on a transmission line section.

[0016] **Figure 4** is a side view of a load coil switching terminal installed on a transmission line section according to embodiments of the present invention.

[0017] **Figure 5** is a front view of a switch panel mounted in a load coil switching terminal according to embodiments of the present invention.

[0018] Figure 6A is a top view of a sliding connector bracket in a load coil switching terminal according to embodiments of the present invention.

[0019] Figure 6B is a top view of an alternate sliding connector bracket in a load coil switching terminal according to embodiments of the present invention.

[0020] Figures 7A-7D illustrate methods of installing a switch panel in a load coil switching terminal according to embodiments of the present invention.

[0021] Figure 8A is a front view of a switch in an upper position for use in a load coil switching terminal according to embodiments of the present invention.

[0022] Figure 8B is a schematic diagram that illustrates the operation of the switch of **Figure 8A**.

[0023] Figure 8C is a front view of a switch in a lower position for use in a load coil switching terminal according to embodiments of the present invention.

[0024] Figure 8D is a schematic diagram that illustrates the operation of the switch of **Figure 8C**.

[0025] Figures 9A-9H illustrate methods of installing a load coil switching terminal according to embodiments of the present invention.

Detailed Description of Embodiments of the Invention

[0026] The present invention now will be described more fully hereinafter with reference to the accompanying figures, in which embodiments of the invention are shown. This invention may, however, be embodied in many alternate forms and should not be construed as limited to the embodiments set forth herein. Accordingly, while the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the invention to the particular forms disclosed, but on the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims. Like numbers refer to like elements throughout the description of the figures. Thicknesses and dimensions of some components may be exaggerated for clarity. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

[0027] **Figure 4** illustrates a load coil switching terminal installed on a transmission line section according to embodiments of the present invention. The load coil switching terminal **400** is connected to a telephone pole strand **410** via a strand hanger **415**. The design of the strand hanger **415** and methods of connection therewith are well known to those having skill in the art and need not be described further herein.

[0028] Still referring to **Figure 4**, the load coil switching terminal **400** is connected to an existing load coil enclosure **420** and a transmission line **440**. The load coil enclosure **420** and transmission line **440** together form a transmission line section **430**. The load coil enclosure **420** contains a plurality of load coils, each of which is connected to a respective one of the plurality of wire pairs contained within the transmission line **440**. As the load coil switching terminal **400** is a separate unit, it can be connected between the existing load coil enclosure **420** and the transmission line **440** without having to replace the entire existing load coil enclosure **420**. The load coils in the enclosure **420** are connected to the load coil switching terminal **400** through a load coil enclosure cable **450**. Although the load coil switching terminal **400** is illustrated as installed on a telephone pole **460**, such terminals may also be installed in cabinets, underground manholes, and/or anywhere else that existing load coil enclosures may be located.

[0029] **Figure 5** illustrates the inside of a load coil switching terminal according to embodiments of the present invention. As shown in **Figure 5**, the load coil switching terminal **400** includes a switch panel **500** that contains a plurality of switches **510** which can be accessed by removing the load coil switching terminal cover **520**. The switch panel **500** is pivotally mounted to the terminal housing **530**, such that the panel **500** can be extended from and retracted within the housing **530** by rotating the panel about the mounting point as appropriate for access. The terminal housing **530** may contain a plurality of switch panels **500**, each of which may be pivotally mounted to the terminal housing **530** such that each panel **500** can be rotated about one of a series of substantially parallel axes of rotation.

[0030] The number of switches per panel and the number of panels per terminal may be reduced or increased based on the number of load coils on the transmission line, such that one switch per load coil is provided. For example, for a load coil enclosure with 600 load coils, four switch panels may be mounted within the terminal housing with a capacity of 150 switches per panel, for a total of 600 switches

per terminal. Thus, each terminal may be filled to a different capacity of panels and switches to accommodate a different number of load coils contained within each load coil enclosure.

[0031] Figure 6A illustrates a sliding panel connector bracket in a load coil switching terminal according to embodiments of the present invention, as seen from a top view of the terminal. Referring to **Figure 6A**, the sliding panel connector bracket **600** is used to mount each switch panel to the terminal housing **530**. The sliding panel connector bracket **600** includes a slide pin connector sleeve **610** and a series of panel connector holes **620**. The slide pin connector bracket **600** is mounted to a top portion of the terminal housing **530** via a slide pin **640**. The slide pin **640** rests inside the slide pin connector sleeve **610**, such that the connector bracket **600** can extend from and retract within the terminal housing **530**. An identical sliding panel connector bracket **650** may be mounted to a bottom portion of the terminal housing **530** (see **Figure 7A**). Each panel **500** as illustrated in **Figure 5** may be pivotally mounted to one of the panel connector holes **620** on the connector brackets **600** and **650**. As such, the panels **500** may be easily accessed when the connector brackets **600** and **650** are extended from the terminal housing **530**.

[0032] Figure 6B illustrates an alternate sliding panel connector bracket according to embodiments of the present invention. As shown in **Figure 6B**, the sliding panel connector bracket **600'** includes a slide pin connector sleeve **610'** and a series of panel connector holes **620'**. The slide pin connector bracket **600'** is mounted to the terminal housing **530** via a slide pin **640** in a manner identical to that described above with reference to **Figure 6A**. However, the sliding panel connector bracket **600'** is crescent-shaped, such that the connector bracket **600'** can extend from and retract within the terminal housing **530** and can be rotated with a greater range of motion than the connector bracket **600** of **Figure 6A**. As such, the panels **500** of **Figure 5** may be more easily accessed when the connector bracket **600'** is extended from the terminal housing **530**.

[0033] Figures 7A-7D illustrate a method of installing a switch panel in a load coil switching terminal according to embodiments of the present invention. Referring to **Figures 7A-7D**, the terminal housing **530** includes upper and lower panel connector brackets **600** and **650**, each of which is attached to the housing **530** via a respective slide pin **640 (Figure 7A)**. The panel connector brackets **600** and **650** have a series of panel connector holes **620** (as shown in **Figures 6A** and **6B**) for mounting

switch panels **500**. A spring-loaded pin **710** is mounted at one end of the switch panel **500**. The spring-loaded pin **710** has an upper cap **720** and a lower cap **730** which are configured to be received by the panel connector holes **620** in the panel connector brackets **600** and **650** (**Figure 7B**). To install the panel **500** in the terminal housing, the upper cap **720** of the spring-loaded pin **710** is first inserted into the panel connector hole **620** of the upper connector bracket **600** (**Figure 7C**). Then, the lower cap **730** of the spring-loaded pin **710** is inserted into the panel connector hole **620** of the lower connector bracket **650** (**Figure 7D**). Spring-loading of the lower cap **730** may enable it to be recessed into the spring-loaded pin **710** when pressure is applied, to ease insertion. To remove the panel **500** from the housing **530**, the process can be reversed.

[0034] Figures 8A-8D illustrate a switch for use in a load coil switching terminal according to embodiments of the present invention. Referring to **Figures 8A-8D**, the switch **800** is connected to an incoming wire pair **810** from the central office and an outgoing wire pair **820** to the user/subscriber. The switch **800** is also connected to a load coil **830** in a load coil enclosure via incoming and outgoing leads **840** and **850**. The switch **800** has an upper position (**Figure 8A**) and a lower position (**Figure 8C**). The switch **800** may be manually operated between the upper and lower positions, or may be operated electronically from a remote location.

[0035] Figure 8B illustrates the operation of the switch in the upper position, as shown in **Figure 8A**. Referring now to **Figure 8B**, when the switch **800** is in the upper position, the load coil **830** is electrically connected in series between the incoming wire pair **810** and the outgoing wire pair **820**. This configures the wire pair for voice service, as the load coil **830** reduces the effective capacitance of the transmission line while preventing the passage of high-frequency signals.

[0036] Figure 8D illustrates the operation of the switch in the lower position, as shown in **Figure 8C**. Referring now to **Figure 8D**, when the switch **800** is in the lower position, the incoming and outgoing wire pairs **810** and **820** are electrically connected to each other, such that the load coil **830** is bypassed. This configures the wire pair for high-frequency data transmission, such as DSL. Thus, wire pairs can be quickly configured for voice-only or high-frequency data transmission by selectively connecting the respective load coils, without having to physically remove existing load coils from the respective wire pairs. Further, this can be accomplished without

having to replace any existing load coil enclosures that are already in service, thereby reducing costs.

[0037] **Figures 9A-9H** illustrate a method of installing a load coil switching terminal on a transmission line section according to embodiments of the present invention. As shown in **Figures 9A-H**, a strand hanger **415** is mounted on a telephone pole strand **410** **(Figure 9A)**. The load coil switching terminal housing **530** is mounted on the strand hanger **415**. Next, terminal braces **910** are attached to each end of the strand hanger **(Figure 9B)**. The terminal braces **910** have openings through which the transmission line cable **440** and load coil enclosure cable **450** may enter. The load coil switching terminal cover **520** is attached to the terminal braces **910** **(Figure 9C)**. Switch panels **500** are then placed within the terminal housing **530** according to the method described above with respect to **Figure 7A-7D** **(Figure 9D)**. Each panel may contain a different number of switches **800** mounted on each panel **500** **(Figure 9E)**.

[0038] The twisted wire pairs from the transmission line cable **440** are then connected to the switches **800** on each of the panels **500** in the housing **530** **(Figure 9F)**. Each wire pair is connected to a respective switch **800**, and each switch **800** is connected to a respective load coil **830** in the load coil enclosure **420** through the load coil enclosure cable **450**. Some transmission line cables **440** may include such a large number of wire pairs that the sheer volume of wires is physically unable to be contained within the terminal housing **530**. As such, the switches **800** may be connected to the wire pairs using "punch-down" connectors to reduce the volume of wire pairs within the terminal housing **530**. Any unused wire pairs may be connected to the strand hanger ground connection **920**.

[0039] After connecting the transmission line cable **440** and the load coil enclosure cable **450** to the switches **800**, the load coil switching terminal cover **520** is secured over the terminal housing **530** **(Figure 9G)**. The cover **520** may be latched using metal locks or the like **(Figure 9H)**. As such, load coils may be added or removed from the transmission line by simply opening the cover **520**, accessing the desired panel **500**, and changing the position of the respective switch **800**, without resorting to time-consuming wire splicing and/or load coil enclosure replacement.

[0040] The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many

modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. As such, all such modifications are intended to be included within the scope of this invention. The scope of the invention is to be defined by the following claims.